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ABSTRACT

This paper presents an overview of three-dimensional media technologies (3Dmt). Many of the new 3Dmt are the direct result of interactions of computing, communications, and imaging technologies. Computer graphics are particularly well suited to the creation of 3D images due to the high resolution and programmable nature of the current displays. Computer animation in film making is one example. Research has been undertaken in both conventional television and video display technology and in specialized applications. Autostereoscopic or "glassless" 3D television applications are also being developed. Recent advances have been made in real-time computer generated holography; it demands a high level of involvement and interaction since the virtual information space exists in the mind of the viewer. Three dimensional film technology has been in use for over 100 years. Widespread public exposure to high-quality 3D films can be found in the Disney theme parks and at many other special venues and international expositions. As interactivity in communication media gained importance, virtual realities became the 3D environment of the user/audience through which they can perform their own acts of creative experience. Research at the 3Dmt Center in Montreal (Canada) has centered on a systemic approach to 3D media from a biocybernetic viewpoint, which concerns how the human sensory system responds to and processes information. A new generation of visually literate users is emerging as use of 3D media technologies becomes more widespread. Five figures present information on 3D technologies. (Contains 18 references.) (AEF)

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THREE-DIMENSIONAL MEDIA TECHNOLOGIES: POTENTIALS FOR STUDY IN VISUAL LITERACY

by
Hal Thwaites

Abstract

The three dimensional representation of *reality* has suffered from chronic misconceptions over the years. Presently, there is a wealth of renewed research in 3D being undertaken on a global scale. This paper presents a brief overview of three-dimensional media technologies (3Dmt) such as holography, 3D film, 3D video/TV, virtual realities, and computer imaging. Future issues and concerns conclude the discussion.

Introduction

Our fascination with attempts to create the third dimension is nothing new, extending from the time of early stereoscopes, into the realm of virtual realities. The notion of 3D has always given reference to more *realness*, as human perception functions in a 3D mode. Today we seek to heighten our mediated experiences with continued efforts toward perfecting spatial imaging systems. 3D is the *buzz-word* of the 1990's even though not all of the '3D' is factually stereoscopic in nature. 3D computer graphics abound on television. 3D modeling is applied in many technical and scientific fields, 3D concepts are used in spatial environment design, while 3D medical imaging presents a *more real* look inside the body. The concept of 3D has even been extended to encompass the theory of human memory (Pribram, 1991). 3D as a mode of human thinking, is indeed becoming ubiquitous.

Current media

In this last decade of the twentieth century, new media are evolving from a joint metamorphosis resulting from the merging of computing, communications, and imaging technologies, exemplified by

Figure 1.

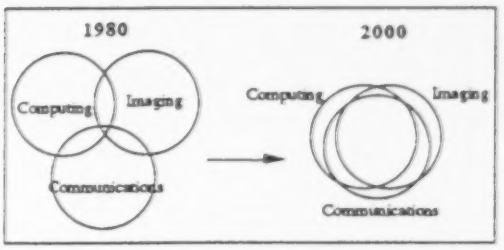

Figure 1. Convergence of Media

It is at the *intersections* that many new forms of media are developing. This merging is shaking things up (Leebaert, 1991). Many of the new 3D media technologies are the direct result of these new interactions. The computer is now an integral part of both the creation and display of stereoscopic images and spatial sound, which was unheard of on the present scale and sophistication, a decade earlier.

Impediments to which we have resigned ourselves are being smoothed, and altogether new products and media are becoming possible. The way to figure out what needs to be done is through exploring the human sensory and cognitive system and the ways that humans most naturally interact (Brand, 1987).

Three-dimensional media technologies (3Dmt) have always presented a challenge to researchers in their acceptance and widespread application as mass media. Throughout their evolution they have been applied in situations where we seek to create a more accurate representation of: *reality*, whereby 3D adds critical information to actual images; *meta-reality*, where 3D technologies make visible phenomena or experiences which are beyond what we

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can naturally perceive; and more recently in *virtual reality*, involving the creation of totally artificial environments which might not physically exist or exist only in our imaginations.

Computer Imaging

Computer graphics (CG) are particularly well suited to the creation of 3D images due to the high resolution and programmable nature of the current displays. There are several proprietary 3D CG systems available in both the United States and Japan. Alternating frame technology is most often employed to present the viewer with the appropriate (right and left eye), stereoscopic images which are then viewed with LC (Liquid Crystal) shutter glasses, such as the systems made by Tektronix and the Stereographics Corporation (Robinson, 1990). A flat panel back-lit LC display, using a lenticular screen for autostereoscopic (glassless) viewing, has been developed by Dimension Technologies Inc. of New York. This system is full-colour, and can be interfaced with common PCs (Eichenlaub & Martens, 1990). Applications of 3D in the CG field include the following: satellite mapping and cartography, CAD, medical displays of CT and MRI images, scientific visualization, weather analysis, interactive modeling, simulation and the military (Lipton, 1988).

Computer graphics have also been used in film making, where the images are screened via conventional polarized projection techniques, after the initial creation of left-right views in a digital form. An example of the commercial application of 3D computer graphics is the award winning stereoscopic, animated short film entitled "Knickknack" (Alspektor, 1989), produced by Pixar of San Rafael, California.

Even more important for the advancement of 3D computer animation was the overwhelming success of the new 70mm. Imax format computer generated SOLIDO™ 3D film, "Echoes of the Sun," which was co-produced by the Imax Corporation of Canada and Fujitsu of Japan for the Osaka, EXPO'90 exhibition.

Thirty-one thousand high resolution computer images (right-eye and left-eye views) were created using Fujitsu's supercomputers over the period of twenty-one months, in order to produce the ten minutes of stereoscopic CG frames incorporated in the twenty minute Imax film. *Echoes* was the world's first IMAX SOLIDO™ full color 3D wrap-around motion picture which is projected on a spherical screen, totally eliminating the cut-off effect of the frame. The film shows how the process of photosynthesis converts the sun's energy into the energy stored in plants and then how this energy is used by humans for motion of muscles. This film also played to capacity audiences at EXPO'92 in Seville, Spain (Naimark, 1992), and is on permanent exhibit at the Futuroscope Complex in La Villette, France in addition to a new SOLIDO™ theatre recently built outside Tokyo, Japan.

Television and Video

Significant research has been undertaken in both conventional NTSC television and video display technology and in specialized applications (Smith, 1989). Japanese researchers are working towards 3D TV systems which may ultimately find way into our homes. Toshiba has marketed a consumer 3-D Camcorder, using LC shutter glasses and a conventional NTSC television monitor. The system provides an acceptable 3DTV image, (with some flicker due to the low frame rate), for certain consumer entertainment applications. Other NTSC video systems which operate at a higher frame rate, to eliminate the image flicker, have been applied in the medical and scientific fields.

Research into autostereoscopic or *glassless* 3DTV is being carried out on an international scale (Hamasaki, 1990) including work at the Institute of Industrial Science at the University of Tokyo, using

the Braun tube technology and at the Heinrich-Hertz Institute in Berlin using projection methods. NHK television in Japan has made important steps toward autostereoscopic TV with the exhibition of a 70-inch LC display at the recent NHK Science and Technical Research Labs 1993 Open House in Tokyo. The key technologies supporting this stereoscopic display are 3D HDTV cameras, HDTV laser videodisc players, high performance HDTV liquid crystal (LCD) video projectors with resolution totaling nine million pixels, and a large size lenticular screen, for glassless viewing. This 3D Hi-Vision display system has widespread application in the fields of home 3D HDTV, art museums, entertainment, medicine, education, robotics, and virtual environment systems.

The HDTV'90 Colloquium in Ottawa, Canada, was the site for the North American premiere of the NHK stereoscopic Hi-Vision 3DTV system. This system uses a conventional polarized projection technique. The viewer wears high quality polarizing glasses to view a projected image on a screen up to two hundred diagonal inches in size (Yuyama, 1991). The images are extremely stable, flicker-free, bright and of high resolution, providing an excellent viewing experience for the audience, with none of the side effects which were the typical complaints of older 3D video projection technologies. Current programs range from recorded art treasures, travel scenes, underwater sequences, medical images to complete works of fiction for entertainment.

The rock group, *The Rolling Stones* used the PullTime™ 3D technique (based on the Pulfrich effect, viewable with or without the special glasses), designed by Gerald Marks of New York City, to create 3D effects for three of the songs in their 1990 *Steel Wheels* concert video which was broadcast widely on cable music channels throughout North America. Altogether these developments represent a concerted effort to bring three dimensional television to the largest possible audience, since TV is the most pervasive mass medium of the late 20th century. For details and characteristics of the current 3D television systems, refer to Figure 2.

Holography

Spatial imaging using the medium of holography has had widespread recognition with the proliferation of holograms in our daily lives. However it still remains much of a mystery to the general public. As a result of the work carried out at the MIT Media Lab, under the direction of Dr. Stephen Benton, holograms have progressed to encompass full color, large scale size, and totally synthetic generation via the computer.

Recent advances have been made in real-time computer generated holography. Although the images are small, they are bright, have high resolution and exhibit all of the depth cues found in holography (Hilaire, Benton, et al., 1990). These are the first steps towards what could be called *holographic video*. We are still many years away from having floating 3D images beamed into our homes. Current applications of holographic imaging include large format displays, full colour holograms, motion stereograms, medical images from MRI data, satellite survey data, and many others, ranging from entertainment to advertising.

The human impact of holography lies in the fact that the image is *perceptually* attached to the viewer's eyes. It demands a high level of involvement and interaction since the virtual information space exists in the mind of the viewer (Malik & Thwaites, 1990). This medium has a radically different means of communication from 3D media presented on a flat surface. Here the existence of the screen or frame effect is removed and the absence of spatial cues (except those presented within the holographed object) cause the strongest information impact on the viewer. Holography is governed more by the laws of scenography (the spatial organization and orchestration of an event or medium), (Polieri, 1971), within the realization of the full 28 axis of a Necker Cube (see

Three Dimensional Television Systems					
System	*Key Principle -Tech.*	*Eyeglass Type*	*Viewable Without*	*Delivery System*	*Comments*
Spatial Technology	Color-discriminatory anaglyphic	Red/green anaglyphic	No	TVbroadcast, videocassette	Color not always natural, images lose sharpness
Nuoptix	Color-discriminatory anaglyphic with Pulfrich Effect	Dark purple/ pale green lenses	Yes	TV broadcast, videocassette	Needs motion within image for 3D effect. Halo around images seen without glasses
PullTime 3-D	Pulfrich Effect	Clear/Dark lenses	Yes	TV broadcast, videocassette	Needs motion within image for 3D effect.
3-D TV (Toshiba, etc.)	Polarized plane discriminatory	Polarized & synchronized LCD	No	TV broadcast, videocassette, videodisc	Good colors, excellent spatial effects, marred by dimness & flicker
Vision II	Parallax & time discriminatory, autostereoscopic	None	Yes	TV broadcast, videocassette, videodisc, film	Very good texture, depth enhancement, full color
Braun Tube (Hamasaki Lab)	Autostereoscopic Lenticular sheet	None	Yes	Closed circuit, real-time	Bright images, presently only monochromatic
3D Projection (Heinrich-Hertz Inst.)	Autostereoscopic Lenticular screen, projection	None	Yes	Closed circuit, real-time	Bright, wide-angle motion parallax, monochromatic
3D Plasma (Flat Panel) (NHK)	Autostereoscopic Lenticular screen plasma display	None	Yes	Closed circuit	Glassless, flat pane monochromatic
70" 3D HDTV (NHK & Sanyo)	Autostereoscopic LCD projection lenticular screen	None	Yes	TV broadcast, videocassette, videodisc	No glasses, large screen, full color, hi-resolution
180" 3D Hi-Vision (NHK)	High Definition polarized, video Projection	2 channel, polarized plane discriminatory	No	TV broadcast, videocassette, videodisc	High-definition bright, wide-screen digital sound

Figure 2. Overview of 3D television systems

Figure 3). Since the viewer is not rigidly seated in a precise position, and is able to move through the holographic space, many of the spatial cues laboriously created on a 2D flat screen are not necessary, since the viewer now experiences them in a spatial, bodologic fashion.

Film/Cinema

Three dimensional film technology has been in use for over one hundred years, extending from the first screening at the Paris International Exhibition of 1890. After experiencing two brief periods of a 3D film boom, the first in 1953 and the second in 1982, we find that today's 3D movies are far from conventional media experiences. Widespread public exposure to high-quality 3D films can be found in the Disney theme parks with films such as "Magic Journeys" and "Captain EO," and at many other special venues and all recent international expositions.

Science North, outside of Sudbury Ontario, opened a 3-D 70mm film and

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laser adventure entitled "Shooting Star" in the summer of 1990. This film incorporates special in-theatre laser effects which are synchronized with the 3-D film scenes to create a totally unique viewing experience. The theatre is specially constructed to maximize the audio-visual experience for the audience. The story is written around an ancient Indian legend which blends the high-tech 3-D imagery into a mystical and involving tale.

The Imax Corporation of Canada has been the world leader in ultra-large screen, 3D productions using IMAX 3D and the new SOLIDO 3D system, which uses the domed screen (Naimark, 1992). These films are evidence of the *meta-reality* aspect of 3D. Todays' 3D film experience takes us far beyond the reality of our physical world, to totally new experiences through the use of the third dimension. There are currently four new 3D IMAX films in production. It is certain that 3D film technology in its many forms will continue to be a prominent form of mass entertainment well into the next century.

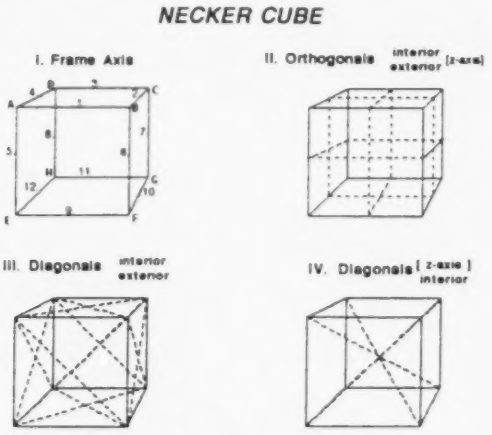

Figure 3. Necker Cube

Virtual Reality/Simulation

By the end of the 1980s *virtual reality* was understood to be a surrogate or metaphysical environment created by communications and computing systems (Wright, 1990). Interactivity in communication media began to rise in importance allowing virtual realities to become the 3D environment of the user/audience through which they can perform their own acts of creative experience.

Current systems being used for the creation of virtual realities consist of: a wide-angle stereoscopic display unit (LCD), glove-like devices for multiple degrees-of-freedom tactile input, speech recognition technology, gesture tracking devices, 3D auditory display and speech-synthesis technology, computer graphic and video image generation equipment. When combined with magnetic head and limb position tracking technology, the head-coupled display presents visual and auditory imagery that appears to completely surround the user in 3-space (Fisher, 1990).

Even at this early stage, virtual realities are touching the realm of the very private *mindspace* of the user, rendering the VR medium a welcome change from the information overload of today's mass communication media. Computer technologies, combined with the development of sophisticated software programs and expert systems, gave early attempts to create virtual realities the insatiable breadth and depth of the human mind's fantasy. Now it is possible to realize 3D virtual realities outside the human brain as a non-separable and inclusive world that is entered and crossed at the pace of the user, being co-created by them.

A Biocybernetic Viewpoint on 3D Media

Our research at the 3Dmt Center in Montreal has centered on a systemic approach to 3-D media, from a biocybernetic viewpoint. The field of biocybernetics is concerned with how the human sensory system responds to and processes information, and the resulting impact it has on us. Our main focus has been with the individual, either observing or creating the three dimensional media program. This is an area of an information

process or information chain. By the term information, I mean an energetic change with a catalytic characteristic, which produces an impact on the viewer (Thwaites & Malik, 1987). The information chain in its simplest scheme, has three parts as described in Figure 4.

Information Source →	Transmission Conditions →	Responding Receiver/s
3DTV, film hologram, VR	room, cinema theater, exhibit	individual, group, audiences

Figure 4.
Information Chain Scheme

Each part of the 3D media event (the program itself, the room and means by which it is perceived, and the person(s) perceiving it), can contain parts of the final information. If any part of the information chain is altered, the information itself is changed. The incoming information acts as a catalyst to other mental processes which occur due to the processing and storage of information in the viewer's brain and can thus affect the overall impact. As 3D media become more sophisticated and interactive, respect for the information chain and information design of the software/hardware interfaces will be of utmost importance to their success (Malik & Thwaites, 1990). The increased time and budgetary constraints that are often placed on 3D media projects leave little room for costly experiments and wasted resources. Protocols and methodologies for information design are included in the publication listed by the author (Thwaites & Malik, 1987).

3Dmt Outlook

From a research standpoint, the author can identify the following concerns for the future: a) The implementation of 3D technologies and production practices in the media of film, television, computers, virtual realities, sound, and dataspace (numerical imaging of space for researchers working predominantly with numbers); b) research into spatial impact: history, basics, biometry and biocybernetics, c) measurement of 3D space in the human mind; d) the application of information design methodologies to three dimensional media production practices; and e) the development of common standards and methodologies for future international exchange of R&D in three dimensional media technologies.

The implications for the study of visual literacy are to make the transition from conventional 2D visual images, into the realm of stereoscopic, true spatial imaging applications, whereby 3-space is real and not merely represented or implied through traditional techniques.

There is a substantial difference between technological, psychophysiological and semantic (content related) factors which are responsible for the creation of 3D media technologies, artpieces or programs, and the factors which are responsible for the creation of a 3D media response (information impact) in the viewer. What sometimes amounts to a small, or negligible cue from the point of view of the author (for example the cinematographer, holographer), may be the paramount reason which causes a high, low, or even non-existent 3D information impact for the people, the receivers, who are perceiving it. Therefore, the scale and importance of the 3D cues from the viewpoint of the artist, producer, or viewer, and the technological requirements of each 3D medium, may result in a different hierarchy entirely. This necessitates an information design approach when employing 3D technologies in the production of media artworks.

An entirely new generation of *visually literate* users/receivers is beginning to emerge. The more widely spread 3D media technologies become, the more exposure the general public will have to them (refer to Figure 5). Only through the exploration of the information impact of true spatial imaging, can we, as concerned visual media researchers, be able to develop strategies to educate future media professionals.

3D Media Applications					
TC	*Communication Broadcasting*	*Packaged Programs*	*Presentations & Exhibitions*	*Visual Databases*	*Digital Data Processing*
R	Mass & Specific Audiences	Mass Audience	Mass & Specific Audience/Users	Specific & Public Users	Specialized Users
IS	Home-Theater Sports Events Still Pictures Computer Graphics	Video Games Videodiscs Electronic Cinema Movies Multi-vision	Flight Simulation Virtual Realities Public Displays Education Environmental Images Advertising	Gallery & Museum Collections Catalogues International Treasures	CAD/CAM Architecture Auto Design Satellite data imaging Medical Imaging

Figure 5: Potential and current applications of 3D media technologies (IS=Information Source, TC=Transmission Conditions, R=Receiver)

Conclusion

As 3D media become more pervasive in society, and the fixed perceptual stereotypes of the general public weaken, the role of the 3D *information designer* will become one of increasing importance as we shift toward the media of the next decade. Perhaps in the distant future, someone will look back on the history of the twentieth century and find, like the fourteenth, that it marked a great transition. We now sit on the cusp between the old and new media. Maybe it ushers in a period of a *3D media renaissance*.

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